COMPARISON OF MILKING OPERATIONS IN HERRINGBONE MILKING LAYOUTS FOR LARGE HERDS IN CALIFORNIA

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CONTENTS

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COMPARISON OF MILKING OPERATIONS IN HERRINGBONE MILKING LAYOUTS FOR LARGE HERDS IN CALIFORNIA

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INTRODUCTION

Milk production in the Southwest is big business. In 1966 there were 3,161 market milk dairies producing milk for fluid consumption in California. The average size of California milk cow herds in 1966 was 132 cows, and average size has continued to increase. Dairy cows in California lead the Nation in individual production, with an average per cow of 11,460 pounds of milk and 405 pounds of milk fat.[2] A study of efficiency in milking operations was appropriate for this State because of the large number of large dairies. The methods of handling dairy cows in California are typical of those most commonly used for large herds in warm climates. Dairy operations that are most efficient in California will apply generally to dairies in other States in the Southwest.

In 1966, of California market milk dairies, 538, or about 17 percent, used some kind of elevated milking stalls. Milking layouts with the stalls arranged in a herringbone pattern have been found to reduce labor requirements and consequently the cost of milk production. The use of elevated stalls has continued to increase, and most of the new elevated stall layouts are built in the herringbone pattern.

In general, dairymen who have adopted the herringbone layout list one or more of the following reasons for the change:

(1) A lower investment is required for the milking structure or structures.

(2) With few exceptions, the milking rate per operator is higher for the herringbone. Fewer operators can milk the same herd, or the same number of operators can handle a larger herd.

(3) Since milking operations are easier in the herringbone, the operators are better satisfied and there is less labor turnover.

This study was made to determine the relationship between different sizes of herringbone milking layouts, equipment, and work routines in dairies and their combined or individual effects on operator efficiency in milking cows. A preliminary report on 57 of the herringbone layouts in this study was presented in 1966.[3] This report presents the completed study. Although the detailed data were collected in 1966, the subsequent analysis brought out principles that must still be considered in planning efficient layouts and methods of operation for the sizes and types of dairies studied.

DESCRIPTION OF FACILITIES AND PROCEDURES

The herringbone layouts studied were grouped according to size. The abbreviation (2–4) means two rows of four stalls each; a (2–6) has two rows of 6 stalls each, and so forth. A total of thirteen (2–4), nine (2–5), fifteen (2–6), sixteen (2–8), one (2–9), seven (2–10), and one (2–12) were studied. Each of two dairies had two (2–5) herringbone

[1] Retired.

[2] United States Department of Agriculture, Agricultural Statistics, pp. 367–404. 1968.

[3] Cleaver, Thayer. Performance of herringbone milking layouts for large herds in warm climates. Presented at the 13th Congress of the International Center for Scientific Work Organization in Agriculture, C.I.O.S.T.A., June 21–24, 1966. Brussels, Belgium. 1966.

layouts in the same building, but each is considered as a separate layout in some of the data.

The size of herds in this study ranged from 53 to 760 cows. The number of cows in lactation varied from 37 to 760. Table 1 shows the range in number of lactating cows for the 61 herds studied in this report. Eighteen herds had fewer than 100 cows in lactation. Three of these had fewer than 50, but this group averaged 68 lactating cows. The average for all 61 herds in this report was 188 cows in lactation.

In this group of dairies, 24 machine operators milked 150 or more cows twice daily, with an average of more than 170 cows each; nine milked 180 or more; and three milked 200 or more each. Twenty-four of the dairies were operated by family labor. All others hired all or part of the labor for the milking operations.

Two complete corrals of cows were studied for most dairies, with a maximum of three for any individual dairy. A study of one, two, or three corrals of cows may not give a true average of milking rates for the entire herd of some of the largest dairies, if there are more than three corrals. However, the study is very accurate for determining the methods, routine, and milking rates for the milking operations of most dairies.

Most of the herds were comprised of Holstein. Only 13 of the 61 herds studied were other breeds or a mixture of breeds.

Time studies were made for 2,610 cows, and travel studies for 2,176. Methods for making time-travel studies were previously reported by Cleaver.[4] Stopwatch time data were recorded for each separate part of the milking operation for each cow, as well as for necessary procedures to admit, release, and care for cows during the overall milking time. In addition, the entire milking layout was photographed and measured so a drawing to scale could be made for measuring distances traveled and from which good and bad features of the entire milking layout could be determined.

General information was obtained from owners, managers, milking operators, county dairy farm advisers, and other extension personnel who could give information on location and operation of herringbone dairy layouts.

[4] Cleaver, Thayer. A method of making time-travel studies of farm livestock chores. Presented at 12th International Congress of Scientific Management of Farm Work, C.I.O.S.T.A., June 8–12, 1964. Lafayette, Ind. U.S.A. 1964.

TABLE 1.—*Lactating cows in 61 California dairy herds by number of milking stalls in herringbone layout used*

Number of milking stalls in herringbone layout [1]	Total herds	Herds in 5 size ranges					Lactating cows in each herd	
		Fewer than 100 cows	101 to 200 cows	201 to 300 cows	301 to 400 cows	More than 400 cows	Minimum	Maximum
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
(2–4)	13	6	7	0	0	0	40	175
(2–5)	8	1	4	1	[2] 2	0	70	370
(2–6)	15	9	5	1	0	0	37	208
(2–8)	16	2	8	2	4	0	67	420
(2–9)	1	0	0	0	1	0	350	----
(2–10)	7	0	2	1	1	3	135	760
(2–12)	1	0	0	0	0	1	520	----
Total	61	18	26	5	8	4	----	----

[1] The first figure is the number of stall rows in the herringbone layout. The second figure is the number of stalls in each row.

[2] Each of these two dairies had two (2–5) herringbone layouts in the same building. One study was made for each of the two layouts in one building.

RESULTS AND THEIR SIGNIFICANCE

Time Data and Milking Rates

Most of the general information and time data for the various milking and related operations are given in table 2. Information is not given for the (2–9) and (2–12) dairy layouts, but data from the other 59 dairies are included.

All dairies studied had piped milk and bulk milk tanks. Five (2–4), four (2–5), three (2–6), four (2–8), and four (2–10) layouts had low-level milk pipelines installed on the walls of the operator area and below the cow-stall floor, instead of in the center overhead where most herringbone pipelines were installed.

Two (2–4), three (2–5), one (2–6), and one (2–10) had a milking machine for each stall in each stall row. Half that many is the more common practice.

One (2–4) and two (2–8) had milk-weighing equipment, which was used for each cow each milking. This weighing operation slowed the milking rate and increased the machine-idle time.

Stopwatch time data were recorded for the milking of each cow and for each operation in line 9 of table 2. Operations in lines 6, 7, and 10 also were timed with a stopwatch.

In each size group, detailed data are shown for the three dairies that required the least time for properly doing necessary operations, in proper sequence, while getting good production of a high-quality product. The average and range of values are for all dairies within a group, including the three for which detailed data were given.

The milking rates shown on lines 12 to 16 of table 2 are based on overall milking time. These are convenient and easily obtained measures of milking efficiency.

Machine-minutes per cow and per pound of milk, lines 17 and 18, respectively, were obtained from a stopwatch record of the actual time the teat cups were on each cow. These lines also measure efficiency in the use of machines and, to some extent, whether cows are being overmilked.

The average number of man-minutes to draw a pound of milk, based on overall milking time (OMT), line 19, is an important measure of labor efficiency. Any value less than 0.1 man-minute per pound of milk indicates good use of labor and, to some extent, good production.

Machine-Idle Time

The machine-idle time is the average number of minutes per machine during OMT when machines are not milking, expressed in table 2 as a percentage of OMT. Machine-idle time has little or no relationship to milking layout, unless the operator has trouble in keeping up with the machines. It is more an indicator of the operator's milking practices than of milking layout efficiency if only herringbone layouts are being compared. It may indicate either good or bad practices. Therefore, machine-idle time should be considered with related factors, line 17 to 20, which show machine-minutes and man-minutes per cow and per pound of milk. For example, an unusually long time interval between removal of the teat cups from one cow and placement on the next cow may result if the machine operator follows a poor routine. On the other hand, it may be good practice when an alert operator breaks routine to remove the machine at the moment the cow is milked out and thus avoids overmilking.

Successive Groups of Cows

Table 3 shows, for all herringbone layouts studied, the variation in milking rate when successive groups of cows were milked. All averages are on a "per operator" basis, whether machine operators worked alone or with one or two other operators. Groups varied in size from 16 to 60 cows, but only seven contained fewer than 26.

All machine operators studied showed a decrease in milking rate for milking the second group of cows, but the decrease for three operators was insignificant—less than one cow per hour per operator. The decrease for seven others was small—fewer than 1.5 cows per hour per operator.

Eleven (2–4), nine (2–5), thirteen (2–6), sixteen (2–8), and seven (2–10) herringbone layouts showed a decrease in milking rate when successive groups were milked. Briefly, 56 of 61 dairies, or 92 percent, showed a decrease in milking rate when the second group was milked. This decrease averaged 3.32, with a range of 0.53 to 8.18 cows per hour per machine operator.

Herringbones that had the smallest decrease in milking rate when milking successive groups were the (2–4), (2–5), and (2–6) layouts, each with two

TABLE 2.—*Time and related data for milking operations in herringbone*

Operation or data item	Thirteen (2–4) layouts [1]					Nine (2–5) layouts [1]				
	Dairy A	Dairy B	Dairy C	Av. of all	Range for all	Dairy D	Dairy E	Dairy F	Av. of all	Range for all
General data (number):										
1. Number of operators	1	1	1			1	2	1		
2. Milking machine heads	4	4	4	4.6	4–8	5	5	10	7.2	5–10
3. Cows per machine operator	81	61	120	85	40–130	200	69	123	113	35–200
4. Cows per machine head	20	15	30	22	10–38	40	27	19	24.1	14–40
5. Machines per machine operator	4	4	4	4.6	2–8	5	2.5	10	5.7	2.5–10
Time data (man-minutes per cow):										
6. To admit and feed cows	0.14	0.23	0.17	0.18	0.1–0.3	0.15	0.08	0.17	0.15	0.08–0.2
7. To release cows	0.10	0.14	0.14	0.13	0.1–0.2	0.11	0.08	0.11	0.10	0.08–0.11
8. For milking operations during time study only.[4 5]	1.32	1.38	1.45	1.84	1.3–3.0	1.05	1.58	1.12	1.39	1.05–2.0
9. For milking operations during travel study only.[4 5]	1.39	1.70	1.64	2.04	1.39–3.1	1.14	1.68	1.23	1.53	1.1–2.2
10. For miscellaneous operations [6]	0.09	0.11	0.07	0.27	0.07–0.8	0.05	0.06	0.06	0.10	0.05–0.2
11. For all operations on lines 6, 7, 8, and 10, during time study only.	1.65	1.86	1.83	2.42	1.6–4.3	1.36	1.80	1.46	1.74	1.36–2.5
Milking rates (cows per hour):										
12. Per machine operator during time study only	45.4	43.4	41.3	37.9	25–46	57.0	37.9	53.7	45.4	30–57
13. Per machine operator during travel study only.	43.1	35.2	36.6	35.5	26–43.1	52.8	35.8	49.6	41.2	27–53
14. For both machine operators during time study only.			(8)	51.0	40–62		75.8		[9] 69.8	59–76
15. For both machine operators during travel study only.			(8)	48.7	39–59		71.5		[9] 64.2	53–72
16. Per machine head during both time and travel studies.	11	10	10	9.0	5–11	11	14	5	8.3	5–14
Machine-minutes:[12]										
17. Per cow	5.14	4.57	4.76	5.78	4.57–8.6	5.06	4.00	5.78	5.75	3.7–9.0
18. Per pound of milk	0.25	0.23	0.24	0.33	0.2–0.7	0.24	0.18	0.27	0.31	0.18–0.5
Man-minutes per pound of milk:[5]										
19. During time study only	0.06	0.07	0.07	0.09	0.06–0.2	0.05	0.08	0.05	0.07	0.05–0.1
20. During travel study only	0.06	0.09	0.08	0.10	0.06–0.2	0.05	0.08	0.06	0.08	0.05–0.1
Percentage of machine-idle time:										
21. One machine head for 2 stalls [13]	2.8	12.4	15.8	9.3	2–18	4.2	8.8		4.3	2–9
22. One machine head per stall or milk weighed for each cow.				38.3	35–43			46.0	44.3	33–52

[1] The three dairies whose data were itemized were the best in their respective groups. Average and range values are for all dairies in the group.

[2] One dairy had only five machine heads, which were moved from stall to stall.

[3] Concentrates not fed during milking.

[4] Wash udder, foremilk, dip teat cups, position machine, machine strip, remove machine, hand strip. Not all these operations were performed for each dairy.

[5] Includes all machine operators during overall milking time (OMT), which begins when teat cups are attached to first cow and ends when they are removed from the last cow.

[6] Includes hobbling cows, treating sore teats, delays, washing manure to drain, moving cows to holding pen, etc., if done during OMT.

[7] Seven dairies with one operator. Average for time study of eight dairies with two operators each is 32.1 cows/hr./operator, and for travel study 28.9 cows/hr./operator, which includes dairies H and I.

milking layouts in 60 California dairies, by number of milking stalls

Fifteen (2–6) layouts [1]					Sixteen (2–8) layouts [1]					Seven (2–10) layouts [1]				
Dairy G	Dairy H	Dairy I	Av. of all	Range for all	Dairy J	Dairy K	Dairy L	Av. of all	Range for all	Dairy M	Dairy N	Dairy P	Av. of all	Range for all
1	2	2			2	2	2			2	2	2		
6	6	6	6.4	6–12	8	8	8	7.8	[2] 5–8	20	10	10	11	10–20
185	48	57	73	19–185	150	88	74	98	34–159	208	190	220	149	68–220
31	16	19	16	6–31	38	22	18	25	9–40	21	38	44	27	14–44
6	3	3	4.6	3–6	4	4	4	3.9	3–4	10	5	5	6	5–10
[3] 0.11	0.10	0.07	0.15	0.07–0.3	0.17	0.12	0.13	0.15	0.1–0.3	0.06	0.14	0.14	0.14	0.06–0.2
0.11	0.10	0.07	0.11	0.07–0.2	0.15	0.16	0.16	0.11	0.1–0.2	0.06	0.09	0.17	0.11	0.06–0.2
0.98	1.71	1.60	1.58	0.98–2.6	1.52	1.53	1.47	1.70	1.47–1.9	1.11	1.18	1.35	1.26	1.0–1.6
1.08	1.80	2.20	1.74	1.08–2.8	1.59	1.61	1.58	1.82	1.58–2.1	1.17	1.21	1.48	1.37	1.0–1.7
0.04	0.12	0.25	0.28	0–1.0	0.23	0.17	0.18	0.31	0.17–0.7	0.19	0.40	0.06	0.22	0.6–0.4
1.24	2.05	1.99	2.12	1.2–4.1	2.07	1.98	1.94	2.27	1.9–3.1	1.42	1.81	1.72	1.73	1.3–2.4
61.5	37.5	31.5	[7] 48.9	31.5–62	39.4	39.1	40.9	35.7	33–41	53.9	50.7	44.4	48.7	38–60
55.6	33.4	27.3	[7] 46.3	27.3–59	37.8	37.3	38.1	33.8	30–38.1	51.3	49.6	40.5	45.2	35–60
	75.0	64.4	[10] 64.3	46–75	78.8	78.2	81.7	71.5	65–82	107.9	101.3	88.9	96.7	76–119
	66.8	54.6	[10] 57.7	43–68	75.7	74.6	76.1	68.2	60–76.1	102.6	99.1	81.0	90.4	71–119
9.8	11.8	9.9	[11] 9.2	4–12	10.0	10.0	10.0	8.9	8–10	5	10.0	9	8.6	6–12
4.99	4.42	5.13	5.64	4.4–7.5	5.75	5.66	5.29	6.01	5.2–8.0	4.97	5.57	7.54	6.14	4.6–7.54
0.31	0.21	0.23	0.37	0.2–0.7	0.24	0.24	0.27	0.31	0.2–0.5	0.23	0.27	0.29	0.37	0.2–0.7
0.06	0.08	0.09	0.10	0.06–0.2	0.06	0.06	0.07	0.08	0.06–0.12	0.05	0.06	0.05	0.08	0.05–0.1
0.07	0.09	0.10	0.11	0.07–0.2	0.07	0.07	0.08	0.09	0.07–0.2	0.05	0.06	0.06	0.08	0.05–0.2
12.9	10.4	5.8	7.8	3–16	2.6	3.4	6.9	[14] 5.8	2–35		3.4	2.7	4.1	2–7
			[15] 45.8							54.5			([15])	

[8] Two dairies with two operators each.
[9] Three dairies with two operators each.
[10] Eight dairies with two operators each.
[11] The only (2–6) with 12 machine heads averaged slightly more than 4 cows/hr./machine head.
[12] Machine-minutes begin when first teat cup is attached to cow and end when teat cups are removed.
[13] Milk not weighed for each cow.
[14] Average is 9.2 percent if two dairies that weighed all milk are included.
[15] Only one dairy.

TABLE 3.—*Decrease in milking rate per operator when two successive groups of cows were milked in the same herringbone milking layout*

Item	Number of milking stalls in herringbone layout									
	(2–4)		(2–5)		(2–6)		(2–8)	(2–10)	(2–9)	(2–12)
Number of machine operators per layout	1	2	1	2	1	2	2	2	3	3
Number of layouts studied	11	2	6	3	4	8	16	7	1	1
Average number of cows:										
In first group	40	42	47	47	52	37	39	40	42	44
In second group	34	34	53	42	51	32	32	45	45	32
Decrease in milking rate (cows/hr./operator)	6.88	1.46	7.76	3.95	5.94	4.92	7.78	6.76	4.70	1.00
Do	4.70	1.03	5.35	2.33	3.76	4.10	5.73	6.45	------	------
Do	4.57	------	4.27	2.12	2.98	3.57	5.49	3.96	------	------
Do	2.75	------	4.10	------	2.18	3.45	5.31	2.65	------	------
Average	3.05	1.25	4.96	2.80	3.72	2.95	3.02	3.49	4.70	1.00
Range of values	.53–6.88	1.03–1.46	2.43–7.76	2.12–3.95	2.18–5.94	.42–4.92	.77–7.78	1.05–6.76	------	------

machine operators and in that order. This was largely due to fewer steps and machines than larger layouts required.

Operator Travel Distance

Table 4 summarizes the distance traveled by an operator while doing the milking, preparation, and cleanup operations. Travel in feet shown is for all operators on a per-cow basis. Averages in line 10 of table 4 indicate that the (2–10) layout had the least travel per cow, 39.4 feet, closely followed by the (2–5) and (2–6), then the (2–5), (2–12), (2–9), and (2–8) layouts, in that order. However, since there was only one (2–9) and one (2–12), they were not very comparable with the other groups. They were included to show what is possible with larger herringbone sizes.

The principal reason for greater travel distance in the (2–9) and (2–12) layouts over that of the (2–10) layouts was that the operators, too many times, walked the full length of the operator area when admitting and releasing cows. Most of this excess travel was unnecessary.

The (2–5) layout showed the lowest average distance traveled per pound of milk produced, with 2.4 feet. The final figure for this data, however, depends largely on milk production. Both high-producing cows and low-producing cows require the same minimum essential operations and steps by the operator for proper milking. No data have been developed that might indicate whether the average high-producing cow gets more or less attention than the average low-producing cow. Observations on a large number of slow-milking and low-producing cows over a period of 19 years indicate that these cows usually require more operator time and effort (mostly machine stripping) than the fast-milking and high-producing cows. There is also some evidence from other investigators that most high-producing cows milk out the fastest.

Milking Rates per Operator

Table 5 compares all the operators studied whose milking rate was more than 50 cows per hour. All of them showed a comparatively large number of machine-minutes per cow. Some overmilking was probable in each herd. One useful comparison is "machine-minutes of milking time per pound of milk produced" (last column of table 5). This depends both on milk production per cow and on machine-minutes for milking the cow. A value of 0.25 or fewer machine-minutes per pound of milk is considered very good, assuming

TABLE 4.—*Distance traveled by operator for preparation, milking, and cleanup operations in 61 California dairies using herringbone milking layouts in 1966, by size of layout*

Operation or item	Number of milking stalls in herringbone layout															
	Thirteen (2–4) [1]			Nine (2–5) [2]			Fifteen (2–6)			Sixteen (2–8)			One (2–9)	Seven (2–10) [3]			One (2–12)
	Maximum	*Minimum*	*Average*	*Maximum*	*Minimum*	*Average*	*Maximum*	*Minimum*	*Average*	*Maximum*	*Minimum*	*Average*		*Maximum*	*Minimum*	*Average*	
Number of cows:																	
1. In lactation	175	40	98	370	70	215	200	37	104	318	67	198	350	760	135	352	520
2. For time study	72	32	43	60	40	47	69	24	45	72	31	41	42	70	40	50	44
3. For travel study	72	16	35	60	30	49	69	13	43	72	24	35	41	71	48	56	37
Number of machine operators for:																	
4. Milking	2	1	1.2	2	1	1.3	2	1	1.7	2	2	2	3	2	2	2.0	3
5. Preparation	1	1	1	2	1	1.1	2	1	1.1	2	1	1.2	1	5	2	2.4	3
6. Cleanup	1	1	1	2	1	1.0	2	1	1.1	2	1	1.2	1	5	2	2.0	1
Distance traveled (feet per cow):																	
7. Admitting and releasing cow, feeding concentrates	11.8	5.3	7.6	12.5	6.0	8.7	13.6	4.3	8.2	17.0	2.5	8.9	23.6	18.8	2.5	9.7	18.7
8. Principal milking operations [4]	39.5	17.6	29.0	36.5	14.8	26.2	41.1	17.4	26.5	66.5	23.3	44.4	33.4	34.7	18.2	23.6	23.5
9. Miscellaneous milking operations [5]	19.3	3.1	8.3	19.7	0	8.3	16.5	2.2	7.8	18.3	1.8	8.4	4.1	14.5	2.8	6.1	12.3
10. Total milking and related operations [6]	62.3	32.2	45.2	64.4	29.7	43.3	61.7	24.0	43.9	88.6	34.1	61.7	61.1	56.3	26.8	39.4	54.5
11. Preparation of equipment for milking [7]	8.5	1.7	3.4	6.3	1.8	3.3	7.5	1.1	3.5	7.3	1.0	3.6	1.9	3.4	1.1	2.3	2.1
12. Cleanup of equipment after milking [8]	5.5	1.2	3.3	6.0	1.9	3.4	7.6	1.7	4.1	6.7	1.4	3.1	2.1	4.2	1.2	2.5	1.7
13. Distance traveled (feet per pound of milk) [9]	4.8	1.8	2.6	4.0	1.4	2.4	4.7	1.1	2.9	3.8	1.3	2.5	3.7	6.9	1.3	2.7	3.3

[1] Number of dairies studied and number of stalls in the herringbone milking layout of each. For example, "Thirteen (2–4)" means 13 dairies, in each of which the milking layout had two rows with 4 stalls in each row.

[2] Two of the (2–5) layouts studied were in the same building but were considered separately.

[3] The largest herd of this group, with 760 cows, had two (2–10) layouts in the same building, but only one of them was studied.

[4] Wash udder, place machine on cow; check, aid, and remove machine; handstrip if necessary.

[5] Get drink of water, check milkroom equipment, get extra machine for milking another cow, wash manure to gutter drain, treat cow's sore teats, dip teat cups, delays, to holding pen, etc.

[6] Includes all of items 7, 8, and 9.

[7] Assemble and prepare milkroom equipment and milking machines, attach machines to vacuum and milk pipes in milking area, start vacuum pump, etc.

[8] Return milking equipment to milkroom, clean and sterilize all milking and milkroom equipment, stop vacuum pump, wash milkroom floor.

[9] Distance used is that in item 10.

TABLE 5.—*Time and milk-production data for operators with high milking rates*

Number of machine operators	Number of milking stalls in herringbone layout	Machine heads per operator	Cows per hour per machine operator	Machine-minutes per cow	Pounds milk per cow per milking	Machine-minutes per lb. of milk
		Number	*Number*	*Minutes*	*Pounds*	*Minutes*
1	(2–5)	5	57.04	5.06	21.50	0.24
1	(2–5)	10	53.69	5.78	21.29	.27
1	(2–5)	10	57.07	6.76	21.29	.32
1	(2–6)	6	61.54	4.99	16.08	.31
1	(2–6)	6	56.00	5.93	16.63	.36
1	(2–6)	6	51.06	5.94	14.93	.40
2	(2–10)	10	53.93	4.97	22.61	.22
2	(2–10)	5	50.66	5.57	20.39	.27

that the cow has been milked properly. Sixteen of the 61 dairies studied had 0.25 or fewer machine-minutes per pound of milk. Their average of 0.23 machine-minutes per pound of milk was considerably less than the average time for all dairies studied. The average milk production in these fast-milking dairies—21.28 pounds of milk per cow per milking, was considerably more than the averages for all 61 herringbone layouts studied.

Significant overmilking must be avoided to prevent injury to the cows. This makes the total machine-minutes for milking a cow very important. The collected data do not show great differences in machine-minutes per cow by milking layout size or by number of machine operators. However, some combinations do seem better than others. Table 6 shows this relationship for the best herringbones in each group, where good milking practices were observed and the amount of overmilking was kept to a minimum.

Most well-trained, capable machine operators can use four machine heads properly, and some can manage five. Few, if any, can manage six machines effectively without overmilking. If there are fewer than four machines per operator in a two-or three-man layout, some time is likely to be wasted because of overlapping operations. This is one reason for the high values in table 6 of 0.09 man-min./lb. of milk for the (2–5) and (2–6) layouts with two operators each.

All of the (2–4) herringbone layouts studied had milking rates of fewer than 50 cows/hr. per operator, which was slower than rates in most (2–5) layouts. The basic reason why the (2–5) makes faster milking possible is illustrated in table 7.

Table 7 assumes that the same operator has a choice of milking 20 cows in a (2–4) herringbone layout or milking the same cows in a (2–5) layout. The average time for placing machines on cows is assumed to be 0.2 minute/cow and the average machine-minutes milking time/cow to be 5.0 minutes in both layouts. Assume further that the two layouts have four and five cows, respectively, in them and that milking operations are ready to start. Also assume that a stopwatch is used, and that only running time is recorded for all operations.

The operator starts milking in the (2–4) layout by placing machine No. 1 on the first cow during the time interval of 4.8 to 5.0 minutes, then he places machine No. 2 on the next cow in 5.0 to 5.2 minutes, then cow Nos. 3 and 4 in 5.2 to 5.4 and 5.4 to 5.6 minutes, respectively. Since average milking time is 5 minutes, machine No. 1 will be removed at 10.0 minutes and placed on cow No. 1 of Group 2 (B to C) during the time interval 10.0 to 10.2 minutes. Then machine Nos. 2, 3, and 4 are transferred to other cows in the same order, D to E, F to G, H to I, etc. Milking proceeds in this order until 20 cows are milked.

TABLE 6.—*Machine-minutes and man-minutes to produce 1 pound of milk in herringbone milking layouts in 61 California dairies, averaged by size of layout and number of operators*

Number of machine operators per layout	Number of milking stalls in herringbone layout	Milk per cow per milking	Machine-minutes per cow	Machine-minutes per pound of milk	Man-minutes per pound of milk
Number		*Pounds*	*Minutes*	*Minutes*	*Minutes*
1	(2–4)	20.6	4.93	0.24	0.07
1	(2–5)	21.9	5.77	.26	.05
2	(2–5)	18.7	4.18	.23	.09
1	(2–6)	16.7	5.83	.35	.07
2	(2–6)	20.7	5.10	.25	.09
2	(2–8)	22.6	5.57	.25	.06
2	(2–10)	22.7	6.03	.26	.05
3	[1] (2–9)	16.4	4.89	.30	.12
3	[1] (2–12)	17.9	5.23	.29	.08

[1] Only one dairy.

After machine No. 4 was placed on cow No. 4 in Group 1 at 5.6 minutes, the operator had 4.4 minutes (A to B) before the first machine had to be removed from the first cow. During these 4.4 minutes, he could admit a second group of cows and prepare them for milking. This interval of 4.4 minutes should be ample for most operators. Even when a herd of fast-milking cows milks out in an average of only 4 minutes per cow, there is an average of 3.4 minutes to admit and prepare the next group of four cows for milking, and this should be adequate time. Actually, 14 of the 61 herds studied did milk out in an average of less than 5 minutes. These fast-milking herds consisted of three with (2–4) layouts, three (2–5), five (2–6), one (2–9), and two (2–10).

After the 20 cows were milked in the (2–4) layout, the total overall milking time (OMT) was determined by subtracting 4.8 from 31.4 to get 26.6 minutes. This gives a milking rate of 45.11 cows per hour. This is higher than the average for the (2–4) group as shown in table 2, but two of the (2–4) operators milked slightly more than 45 cows per hour.

Table 7 shows a similar pattern of operations for milking the 20 cows with five machines in a (2–5) layout. The resulting OMT of 21.6 minutes gives a milking rate of 55.56 cows per hour. This is 10.5 cows per hour faster than the rate with four machines.

The reason for this difference is that with four machines there are five groups of four cows each to be released, admitted, and prepared for milking. For each group, 0.8 minute is spent attaching machines to and removing them from four cows, leaving 4.4 minutes to release cows, admit more cows, and prepare the admitted group for milking. For five groups, this changeover must take place four times during the 20-cow milking period.

If the operator has five machines to work with, and if groups of cows can be prepared in 4.2 instead of 4.4 minutes, he can handle the cows in four groups of five cows each. Attaching and removing machines then takes 1.0 minute instead of 0.8 minute, leaving 4.2 minutes to move one group out and get the other group ready. If this time is still adequate for the operator, it needs to be done only three times instead of four.

When the average machine milking time per cow is more than 5 minutes, the advantage of the larger layouts is increased.

If the average milking time per cow is only 4 minutes, then a (2–4) layout is the largest that most operators can manage, because the time interval for preparing the next group of cows will be reduced to 3.4 minutes. In that time, the average

operator can prepare four cows, but he cannot prepare five cows in 3.2 minutes. Maximum proper use of a (2–4) layout for these 4-minute cows would result in a theoretical milking rate of 55.5 cows per hour.

TABLE 7.—*Overall milking times for 20 cows averaging 5 machine-minutes milking time each in a (2–4) herringbone milking layout and a (2–5) layout, with one operator per laycut*

One operator, 20 cows averaging 5 machine-minutes milking time each

Four milking machines

Group of cows	Machine number	Position machine	Milking starts	Remove machine	Item
		Time in minutes[1]	*Time in minutes*[1]	*Time in minutes*[1]	
1	1	4.8	5.0	10.0 B	
	2	5.0	5.2	10.2 D	
	3	5.2	5.4	10.4 F	
	4	5.4	5.6 A	10.6 H	
2	1	10.0 C	10.2	15.2 B	
	2	10.2 E	10.4	15.4	
	3	10.4 G	10.6	15.6	
	4	10.6 I	10.8 A	15.8	
3	1	15.2	15.4	20.4 B	
	2	15.4	15.6	20.6	
	3	15.6	15.8	20.8	
	4	15.8	16.0 A	21.0	
4	1	20.4	20.6	25.6 B	
	2	20.6	20.8	25.8	
	3	20.8	21.0	26.0	
	4	21.0	21.2 A	26.2	
5	1	25.6	25.8	30.8 B	
	2	25.8	26.0	31.0	
	3	26.0	26.2	31.2	
	4	26.2	26.4 A	31.4	

Overall milking time[2] (minutes)	26.6
Milking rate (cows/hour)	45.11
Interval from A to B within group for preparing next group of 4 cows[3] (minutes)	4.4
Number of intervals	4
Total time preparing cows (minutes)	17.6

Five milking machines

Group of cows	Machine number	Position machine	Milking starts	Remove machine	Item
		Time in minutes[1]	*Time in minutes*[1]	*Time in minutes*[1]	
1	1	4.8	5.0	10.0 B	
	2	5.0	5.2	10.2	
	3	5.2	5.4	10.4	
	4	5.4	5.6	10.6	
	5	5.6	5.8 A	10.8	
2	1	10.0	10.2	15.2 B	
	2	10.2	10.4	15.4	
	3	10.4	10.6	15.6	
	4	10.6	10.8	15.8	
	5	10.8	11.0 A	16.0	
3	1	15.2	15.4	20.4 B	
	2	15.4	15.6	20.6	
	3	15.6	15.8	20.8	
	4	15.8	16.0	21.0	
	5	16.0	16.2 A	21.2	
4	1	20.4	20.6	25.6 B	
	2	20.6	20.8	25.8	
	3	20.8	21.0	26.0	
	4	21.0	21.2	26.2	
	5	21.2	21.4 A	26.4	

Overall milking time[2] (minutes)	21.6
Milking rate (cows/hour)	55.56
Interval from A to B within group for preparing next group of 5 cows[3] (minutes)	4.2
Number of intervals	3
Total time preparing cows (minutes)	12.6

[1] Time from admission of first group of cows.

[2] Time from positioning machine on first cow to removing machine from last cow.

[3] Time available for admitting, feeding, preparing next group of cows while machines are milking previous group.

Slow Cows

In the two examples of table 7, if a slow-milking cow in each group delays that group by 1 minute, the resulting milking rates for the (2–4) and (2–5) will be reduced to 38.0 and 46.9 cows/hr., or a drop of 7.1 and 8.7 cows/hr., respectively.

Table 8 shows the percentage of slow cows and faster milking cows for all of the 61 dairies studied. The problem of the slow cows may be managed in several ways.

In small herds not separated into corrals, the few slowest cows may be separated from the herd and milked in special groups.

Slow cows can be removed from the herd and sold.

An alert operator can quickly recognize which of a group of cows entering a herringbone is the slowest milker and put the first available milking machine on the slowest one so that she will be milked out at more nearly the same time as the faster cows. This routine is simplified in herringbones that have a machine head at each stall in both stall rows, because a machine is always available at the moment any cow is ready for it.

Operators per Layout

Two operators of equal ability working together in one (2–8) layout usually will not milk as many cows per hour as their combined rate if each milks alone in a (2–4). One reason is that a slow cow in a (2–8) will delay twice as many cows as she would in a (2–4), and she will delay two operators instead of one. There is also the possibility that two machine operators working together may not be very compatible and help each other as much as they could when a slow cow delays one or the other.

However, if a single (2–8) layout is properly arranged, equipped, and built, it has the advantage of a simpler, less complicated arrangement of lanes, gates, washing and diversion pens, etc. The (2–8) layout probably costs less in most areas than two (2–4) layouts. Two capable, compatible operators can use it efficiently.

TABLE 8.—*Percentage of slow-milking and fast-milking cows in 61 dairy herds in California by size of milking layout used*

Item	Number of milking stalls in herringbone layout									
	(2–4)		(2–5)		(2–6)		(2–8)	(2–10)	(2–9)	(2–12)
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*	*Number*
Machine operators in each layout	1	2	1	2	1	2	2	2	3	3
Layouts studied	11	2	6	3	6	8	18	8	1	1
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fast milkers:										
Less than 3 minutes	4	3	1	23	1	6	3	1	10	2
Less than 4 minutes	16	14	3	46	8	22	10	11	24	23
Less than 5 minutes	39	42	26	79	21	45	28	32	60	50
Slow milkers:										
More than 5 minutes	61	58	65	22	76	55	72	68	41	50
More than 6 minutes	37	26	49	10	49	30	46	45	17	32
More than 7 minutes	22	9	27	2	25	12	26	28	12	11
More than 8 minutes	13	3	8	0	10	6	11	16	2	5
More than 9 minutes	6	0	1	0	0	2	3	6	2	0
More than 10 minutes	6	0	1	0	0	2	3	6	2	0

Eating Time for Cows

Table 9 shows the actual time available for cows to eat their concentrates while being milked. Only the (2–4) and (2–5) layouts with two machine operators allowed each cow less than 10 minutes eating time, but even this time was ample. If cows do not have enough time to eat, some managers arrange for part of the concentrates to be fed elsewhere rather than slow down the milking operations.

Cow Washing

Table 10 shows the amount of time spent washing cows in the herringbone milking stalls studied. This washing probably should have been done in the washing pen, but the older type of sprinkler heads seldom do a thorough job. The newer jet-sprinkler heads are much more effective, and little if any additional cow washing is required in the milking stalls.

Much less time was required for the extra cow washing in the (2–5) group with one operator and the (2–10) group than in the other sizes. These low figures are primarily because three of these (2–5) and four of the (2–10) that had washing pens had jet-sprinkler heads. Elimination of all or most of cow washing in the milking stalls speeds up the milking rate by reducing the time required to prepare cows for milking.

Information is available for installation and use of jet-sprinkler installations. Washing pens should allow about 18 square feet per cow for Holsteins and 16 square feet per cow for the smallest breeds.

Time-Saving Design Features

A comparison of efficiency of herringbone milking layout sizes must assume that, for each, good buildings have been well planned and properly built, with the right amount of good equipment properly used. The dairies studied varied somewhat in layout design features even when the herringbones had the same number of stalls. Although exact data were not separated out, observations showed that certain features seemed to increase efficiency in moving cows rapidly and easily through a herringbone layout.

The operator area between milking-stall rows

TABLE 9.—*Time available for cows to eat concentrates while being milked in different sizes of herringbone milking layouts in 61 California dairies*

Number of milking stalls in herringbone layout [1]	Machine operators per layout	Layouts studied [2]	Milking rate	Eating time for cows	
				Maximum	Minimum
	Number	*Number*	*Cows/hour/operator*	*Minutes*	*Minutes*
(2–4)	1	11	39.51	12.28	12.19
(2–4)	2	2	28.83	9.75	9.48
(2–5)	1	6	50.68	11.46	11.35
(2–5)	2	3	34.91	9.05	8.65
(2–6)	1	6	52.90	12.47	12.38
(2–6)	2	9	31.42	11.67	11.41
(2–8)	2	16	36.72	13.00	12.65
(2–9)	3	1	30.86	11.75	----
(2–10)	2	7	48.68	11.86	11.82
(2–12)	3	1	42.57	10.91	----

[1] Number of rows and number of stalls in each row.

[2] Two of the (2–5) layouts studied were in the same building but were considered separately.

TABLE 10.—*Time required for washing cows in milking stalls in 61 California dairies in 1966, by size of herringbone milking layouts*

Number of milking stalls in herringbone layout [1]	Machine operators per layout	Layouts studied [2, 3]	Time per cow	
			Washing udder [4]	Overall milking time [5]
	Number	*Number*	*Minutes*	*Minutes*
(2–4)	1	11	0.46	1.56
(2–4)	2	2	.63	2.47
(2–5)	1	6	[6].25	1.22
(2–5)	2	3	.53	1.74
(2–6)	1	6	.37	1.18
(2–6)	2	9	.54	1.88
(2–8)	2	16	.41	1.72
(2–10)	2	7	[7].25	1.26
(2–9)	3	1	.34	1.94
(2–12)	3	1	.28	1.38

[1] Number of rows in layout and number of stalls in each row.

[2] Some of these dairies had the old lawn-type sprinkler heads, and some had the newer jet-type sprinkler heads.

[3] Two of the (2–5) layouts studied were in the same building but were considered separately.

[4] These data include only the cow washing that was done in the milking stalls and also fore-milking.

[5] Time actually occupied with a single cow. Does not include time when machine is operating without special attention.

[6] Two herds were washed with jet sprinklers in the washing-pen floor, one herd was washed with a combination of special jets and revolving brushes.

[7] Four herds were washed with jet sprinklers in the washing-pen floor.

should not be more than 5 feet wide. Crowding gates, washing-pen and diversion-pen gates, and washing-pen sprinklers, should all have remote controls in this operator area.

Cow exit gates should not be less than 42 inches wide, and preferably 48 inches where cows must make a 180° turn.

Jet-sprinkler heads should be used in the washing pen for washing cows thoroughly. If sprinkler heads are properly placed and used, they will greatly reduce udder-washing time after cows enter the milking stalls. Cow space in the washing pen must be adequate to allow cows to move around while being washed.

The concentrate-feeding equipment should be dependable, accurate, and durable, with controls at convenient locations along both sides of the operator area.

SUMMARY

Sixty-one herringbone milking-stall layouts were studied to determine their suitability for milking all sizes of California dairy herds. All sizes proved suitable if used properly.

Milking rates per machine operator varied widely in the (2–4) to (2–10) layouts. The only (2–9) and (2–12) studied had three operators each. When compared with the (2–4), the (2–12) proved better on a per-operator basis for chore times and milking rates. Travel per operator in the (2–12) was slightly more than the (2–4) group average. This was because the operator farthest from the cow entrance door drove all slow cows into the milking stalls. Excess travel occurred in the (2–9)

for similar reasons. The (2–9) and (2–12) arrangements do compare well among dairies that have approximately the same milk production per cow but not well when their milk production is higher.

The most important variables in determining how many milking machines an operator could use properly were:

1. Training, ability, and routine of the operator.
2. Time required to prepare cows for milking.
3. Time required for cows to milk out.
4. Design and arrangement of milking layout and operator area.
5. Equipment—condition, type, and controls.

A (2–4) layout with either four or eight milking machines is the maximum an operator can use properly if the milking time averages no more than 4.5 minutes per cow. If the average for proper milking time for the herd is about 5.0 minutes, one good operator can use a (2–5) layout effectively. Under similar conditions, two compatible operators may be able to use a (2–8) or a (2–10) properly.

In a (2–4) layout with one operator or a (2–8) with two operators, milking rates may be as high as 40 to 45 cows/hour/operator. In a (2–5) with one operator or a (2–10) with two operators, milking rates may be as high as 50 to 55 cows/hour/operator.

A (2–6) layout usually is not large enough to keep two well-trained machine operators busy, and it is too large for one-man operations if the average milking time per cow is no more than 5 minutes.

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